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E74-10149
CR-136208

THE INTERDEPENDENCE OF LAKE ICE
AND CLIMATE IN CENTRAL
NORTH AMERICA

Prepared For: National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

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Type: Interim Report for Period
June 1973 - November 1973

Date Prepared: December 1973

(E74-10149) THE INTERDEPENDENCE OF LAKE
ICE AND CLIMATE IN CENTRAL NORTH AMERICA
Interim Report, Jun - Nov 1973 (Wolf
Research and Development Corp.)
\$3 75

CSCL 08L G3/13
Unclas
00149

N74-14017

1. Report No.:
2. Government Accession No.:
3. Recipient's Catalog No.:
4. Title and Subtitle
The Interdependence of Lake Ice and Climate in Central North America
5. Report Date
December 1973
6. Performing Organization Code
7. Author(s)
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8. Performing Organization Report No.
9. Performing Organization Name and Address
*Wolf Research and Development Corporation
6801 Kenilworth Avenue
Riverdale, Maryland 20840*
10. Work Unit No.
11. Contract or Grant No.
NAS 5-21761
12. Sponsoring Agency Name and Address
*National Aeronautics and Space Administration
Goddard Space Flight Center
Greenbelt, Maryland 20771

Frederick Gordon, Jr.*
13. Type of Report and Period Covered
Interim: June 1973 - November 1973
14. Sponsoring Agency Code
15. Supplementary Notes
None
16. Abstract
A comparison of lake freeze transition zone migration with the movement of large pressure centers reveals the following consistencies: (1) polar continental cyclones originate within and/or travel along the trend of the transition zone; (2) polar continental anticyclones fail to cross the transition zone, and (3) polar outbreak anticyclones pass through the transition zone, apparently unaffected. In addition, storm centers associated with the transition zone undergo significant intensification manifest by a deepening of the pressure trough and increased precipitation outside the zone.
17. Key Words (Selected by Author(s))
lake ice, ice survey, meteorology
18. Distribution Statement
19. Security Classif. (of this report)
U
20. Security Classif. (of this page)
U
21. No. of Pages
22. Price*

* For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

TECHNICAL REPORT STANDARD TITLE PAGE

PREFACE

The primary objective of this investigation is to identify any correlations between the freeze/thaw cycles of lakes and regional weather variations. To meet this objective ERTS 1 imagery of central Canada and north central United States are examined on a seasonal basis. The ice conditions of certain major study lakes are noted using standard photo interpretation techniques. The observations are recorded on magnetic tape, and base maps are used to draw the position of the lake freeze/thaw transition zone. Weather data, as available from the National Weather Service, are compared with the transition zone migration pattern to determine any correlations.

Transition zone migration for the month of November, 1972 freeze season, is compared with the flow of weather systems for the same time period. The results are consistent with those previously described [1]:

- Polar continental cyclones originate within and/or travel along the trend of the transition zone.
- Polar continental anticyclones fail to cross the transition zone.
- Polar outbreak anticyclones pass through the transition zone without undergoing any apparent change.

ERTS 1 data from the 1973 freeze season should test the consecutive year consistency of these observations and provide a basis for suggesting rules of air mass flow in central Canada during the freeze season.

Observations from the first half of the 1973 thaw season are presented; these include not only transition zone location, but a new boundary (ice decay boundary) which separates ice-bound lakes from lakes displaying some signs of ice deterioration. This boundary can be correlated with ground truth information supplied by the Atmospheric Environment Service of Canada.

A preliminary comparison of lake mean freeze dates with lake mean depth has revealed a roughly linear variation as a function of latitude. The possibility exists that with additional freeze date observations the mean depths of many isolatidunal lakes can be estimated solely from their freeze dates.

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SECTION 1.0

INTRODUCTION

This report is a comprehensive review of all work performed under contract number NAS 5-21761 during the period from June 1973 through November 1973. The presentation will consist of three parts: (1) the scope of work covered along with the problem areas encountered; (2) the results of ERTS 1 imagery analysis for the 1972 freeze season and 1973 thaw season; (3) recommendations for future work under this project. The discussion will be summarized in a Conclusions Section.

SECTION 2.0 ACCOMPLISHMENTS

In the previous semiannual report [1] under this contract, three task areas were identified for future action:

- Data Analysis Software Development
- Continued ERTS 1 Imagery Analysis
- Transition Zone - Climate Interdependence Study

Progress within each of these task areas is reported on below.

2.1 DATA ANALYSIS SOFTWARE DEVELOPMENT

During the reporting period a scheduled limited effort at software development was successfully implemented. A tape storage program which loads daily extremes in weather station air temperatures was coded and tested on the IBM 360/91 system at NASA/GSFC. In addition, a program utilizing this air temperature data to calculate running mean temperatures was similarly coded and tested. Both routines were added to the program library which is maintained for this investigation; production processing by these routines has begun and is expected to continue through the life of the contract.

2.2 CONTINUED ERTS 1 IMAGERY ANALYSIS

As stipulated by this investigation's Data Analysis Plan, imagery analysis has become the primary work objective for the remainder of the study. In fulfilling that objective

the imagery analysis has concentrated on two subjects of observation: (1) determination of ice state for major study lakes, and (2) mapping the location of freeze/thaw transition zone boundaries.

2.2.1 Major Study Lake Observations

During the 1972 freeze season over 1300 individual ice state observations of major study lakes were made from ERTS 1 imagery [1]. This number has been augmented by an additional 500 observations thus far recorded for the 1973 thaw season.

Despite the large number of observations in absolute terms, when one considers that there are 345 study lakes, the number of ice state observations per lake over the 1972 freeze season averages less than four. Thus, during the entire season the freeze state of any given lake could be determined only on about 3-4 different occasions. In reality these few opportunities are quite reasonable, since the entire freeze season can be covered in four 18-day ERTS cycles; the maximum number of viewing opportunities, allowing for sidelap, would be about 8. These limited occasions should be adequate for this investigation provided they coincide with the freezing or thawing period of the study lake. In practice this has seldom proven to be the case, and the critical time of the lake's ice cycle must be inferred or interpolated from other data and observations.

Cloud cover has proven to be the greatest impedance to lake viewing during the critical ice period, at least for the freeze season. Recent observations made during the thaw season indicate that cloud cover is less of a hinderance at

that time of year. Of course, the ultimate difficulty in viewing individual lakes at any time lies with the 18-day ERTS cycle: the satellite can be over the right place, but at the wrong time.

On the basis of experience gained thus far, ERTS appears unsatisfactory as a tool for observing the dynamics of lake freezing and thawing. However, used in conjunction with other observational data, ERTS imagery can enable fairly accurate estimates of freeze/thaw dates to be made.

2.2.2 Transition Zone Observations

Although individual lake observations have not met original expectations, transition zone observations have exceeded those expectations. At this time imagery have been analyzed for two periods: (1) 1972 freeze season, and (2) 1973 thaw season. The 1972 data have already been described in some detail [1] and need not receive further attention here. The 1973 data, to the extent examined, has proven even more amenable to analysis. A notable decrease in cloud cover has been the principal cause for this improvement.

In contrast to the freeze season imagery, from which ERTS bands 4 and 5 proved most satisfactory for determining ice state, band 7 conveyed the principal information about ice thaw conditions. Under freeze conditions thin, new ice can be more readily detected by the water-transparent bands, whereas decaying, opaque ice best displays its structure in the near infrared. The facility for detecting ice decay structures in the infrared has enabled an "ice decay boundary (IDB)" to be delineated far to the north of the transition

zone. This boundary marks the earliest or first deterioration in ice cover prior to actual thawing to open water.

2.3 TRANSITION ZONE - CLIMATE INTERDEPENDENCE STUDY

Much of the effort of this reporting period has been directed towards identifying and substantiating any correlation between transition zone location and movements and regional weather conditions. Initial efforts in this regard were documented in the last biannual report [1], and a more detailed, unscheduled report was to have been completed early this autumn. This second effort was not completed, partly because of preparations by the principal investigator for an oral disciplinary panel review of ERTS investigations held at NASA/GSFC on 29 October 1973. Delays in the reception of weather data from Canada also hampered progress. Some comparative work has been finished, however, and will be presented here.

Apart from the stated objectives of this investigation our analysis of numerous ERTS scenes has uncovered many fascinating mesoscale meteorological phenomena, including smoke plumes, smog, jet aircraft exhaust and lake-generated snow storms. These phenomena have been discussed in greater detail elsewhere [2,3] and are mentioned here merely as a point of interest.

SECTION 3.0

RESULTS

3.1 FREEZE SEASON (1972)

The 1972 freeze season was probably somewhat shorter than usual, having been accelerated by an unusually cold period lasting from mid-November through mid-December. Many of the lakes of central Canada froze over as much as two weeks ahead of their historical average freeze dates [4]. During the abbreviated freeze season satellite viewing of the land surface was hindered by excessive cloud cover, which for November proved to be the most extensive on record [5]. Despite these difficulties sufficient observational data were available to track migration of the freeze transition zone throughout the months of October and November. These data have been discussed previously [1,3], and need not be duplicated here. Instead this report will describe efforts to correlate such data with available meteorological data from the test site.

3.1.1 Comparison With Weather Systems

Due to exceptional delays in the receipt of Canadian weather data, the thrust of the weather comparison effort was confined to mesoscale weather systems as expressed by pressure centers. The distribution of such centers over the study area is well displayed by North American Surface Charts (1200Z GMT) which the NASA/GSFC Meteorology Section generously supplied.

The movement of major cyclonic and anticyclonic centers was examined in detail for the months of October and November 1972. The daily position of each pressure center was plotted on a base map covering a period of about a week or more. Those pressure centers that dissipated or merged with larger systems after a day or two were deleted from the maps. The remaining centers gave a fairly representative indication of the net movement of weather systems during the period in question.

A comparison of transition zone (TZ) migration with the movement of pressure centers for the month of October has yielded the following [1,3]:

- Many polar continental cyclones originate in and/or travel through the transition zone.
- Polar continental anticyclones fail to cross the transition zone.
- Polar outbreak anticyclones pass directly across the transition zone without undergoing any apparent change.

The above findings were applied to comparative data compiled for November. The motion of pressure centers within the study area for the period October 31 through November 4 is depicted in Figure 1. A polar continental anticyclone passed north of the transition zone, the pressure center having moved along the northern transition zone (NTZ) boundary.

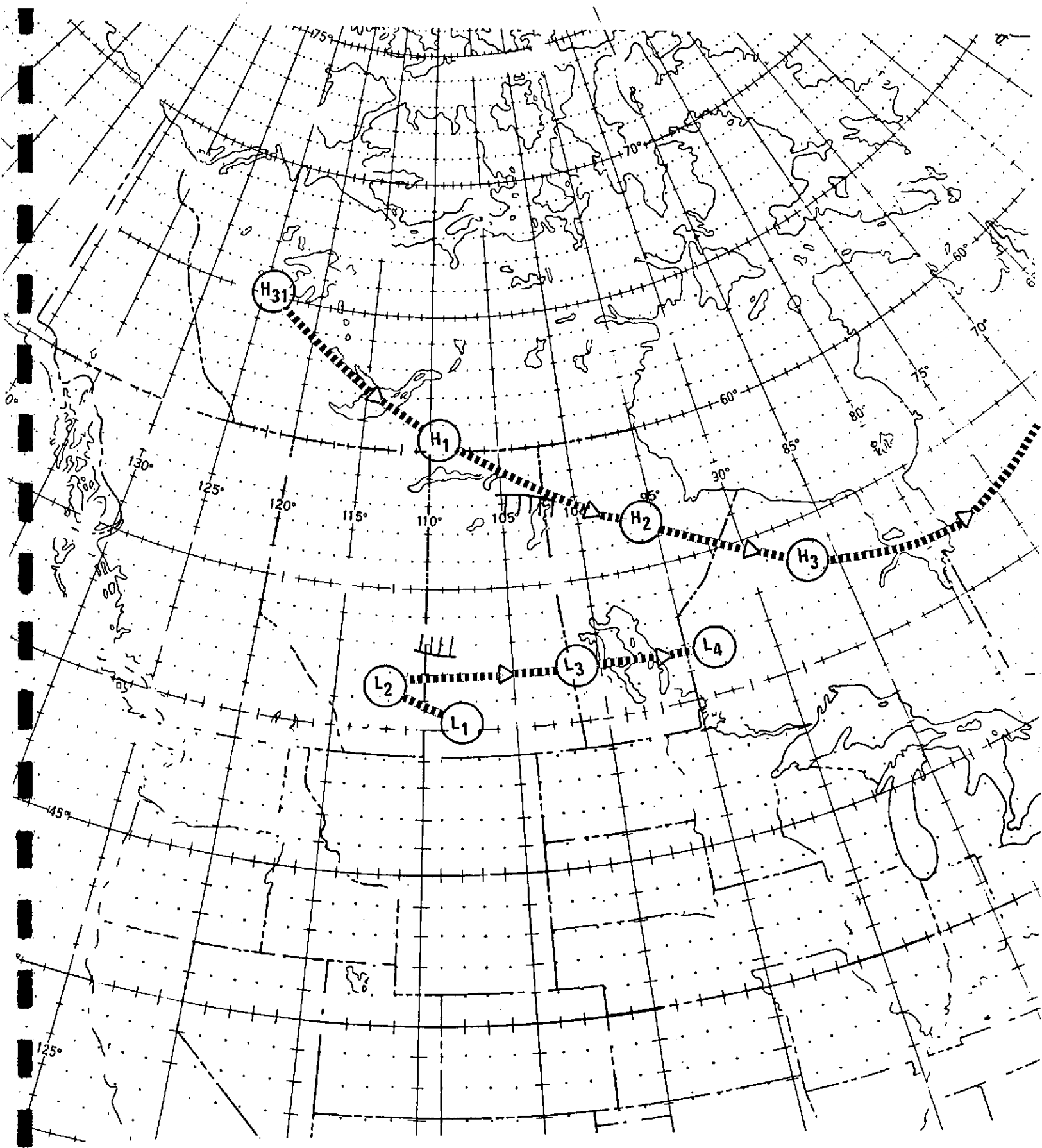


FIGURE 1. MOVEMENT OF AIR MASSES IN CENTRAL NORTH AMERICA BETWEEN 31 OCT 72 AND 04 NOV 72.
(H = High Pressure Mass; L = Low Pressure Mass; Subscript Indicates Day of Month; Observed Transition Zone Indicated)

The period November 10 through November 18 shown in Figure 2 represented a more complex situation. During this time an anticyclonic system moved obliquely across the transition zone, but the movement was sporadic and irregular. There remains some question as to the type of anticyclone represented since weather data for the week prior to November 10 are missing. Doubtless a polar continental anticyclone did cross central Canada on November 15-16 (Figure 2). However, this system moved through southern Alberta-Saskatchewan well to the west of what might be called the effective transition zone of high lake concentrations.

The final case for comparison covers the period November 23 through December 6 (Figure 3). During this period the transition zone ceased to exist as a well defined region of frozen-unfrozen lakes and became instead scattered clusters of open or partly open lakes surrounded by completely frozen lakes. The rapid breakdown of the transition zone can probably be attributed to the exceptionally cold temperatures that characterized this particular time. The weather systems traced in Figure 3 are characteristic of extreme conditions, especially the very large polar cyclone centered over Hudson Bay. This system brought the coldest temperatures for November to south-central Canada and north-central United States [6,7].

The results of comparing transition zone migration with the movement of pressure centers for the month of November do not conflict with those for the previous month. Those consistencies in the movement of pressure centers relative to the transition zone apparently hold for the entire 1972 freeze season. One of the future objectives of this investigation will be to determine whether such consistencies hold up for consecutive freeze seasons.

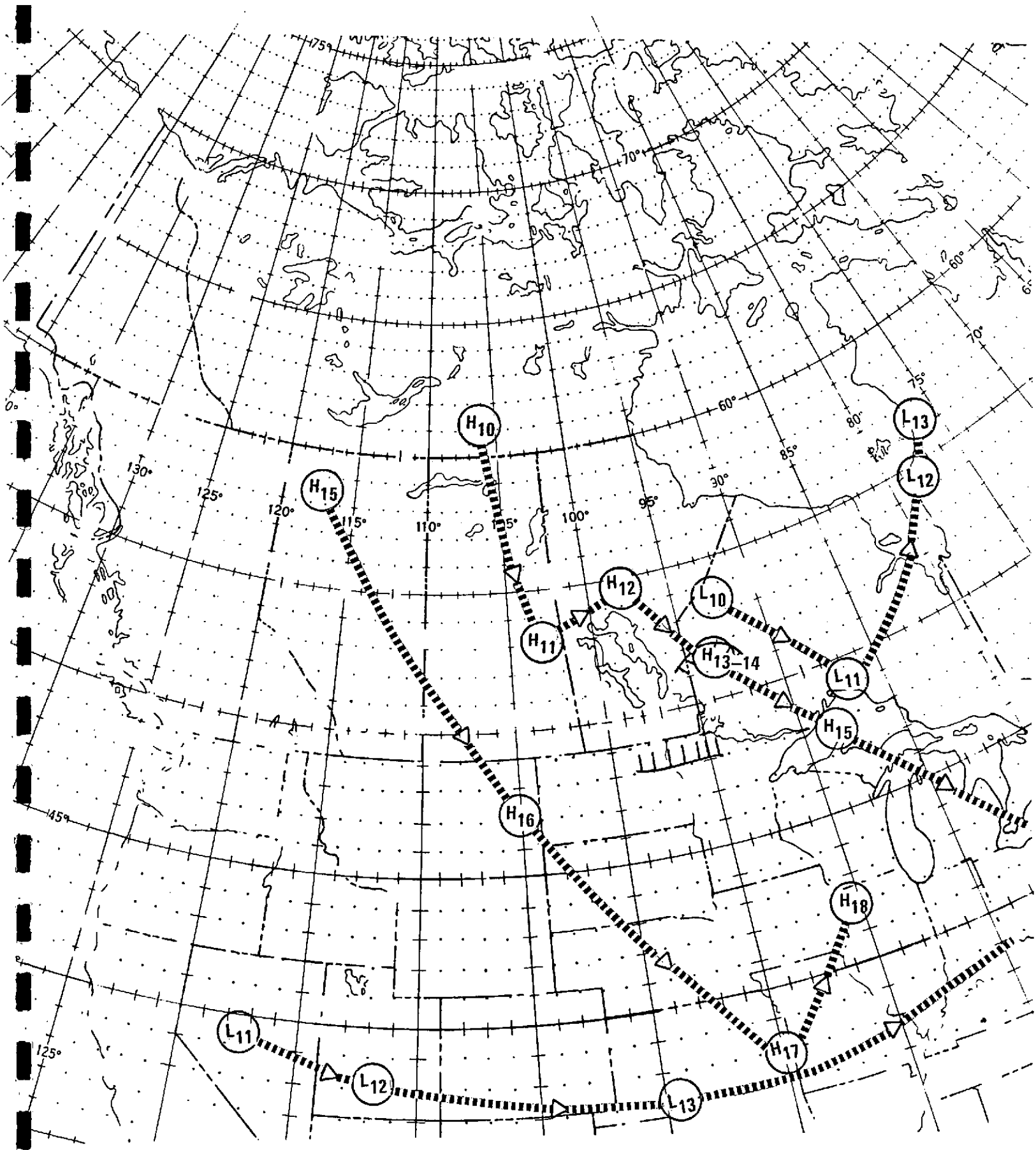


FIGURE 2. MOVEMENT OF IN MASSES IN CENTRAL NORTH AMERICA BETWEEN 10 NOV 72 AND 18 NOV 72. (H = High Pressure Mass; L = Low Pressure Mass; Subscript Indicates Day of Month; Observed Transition Zones Indicated)

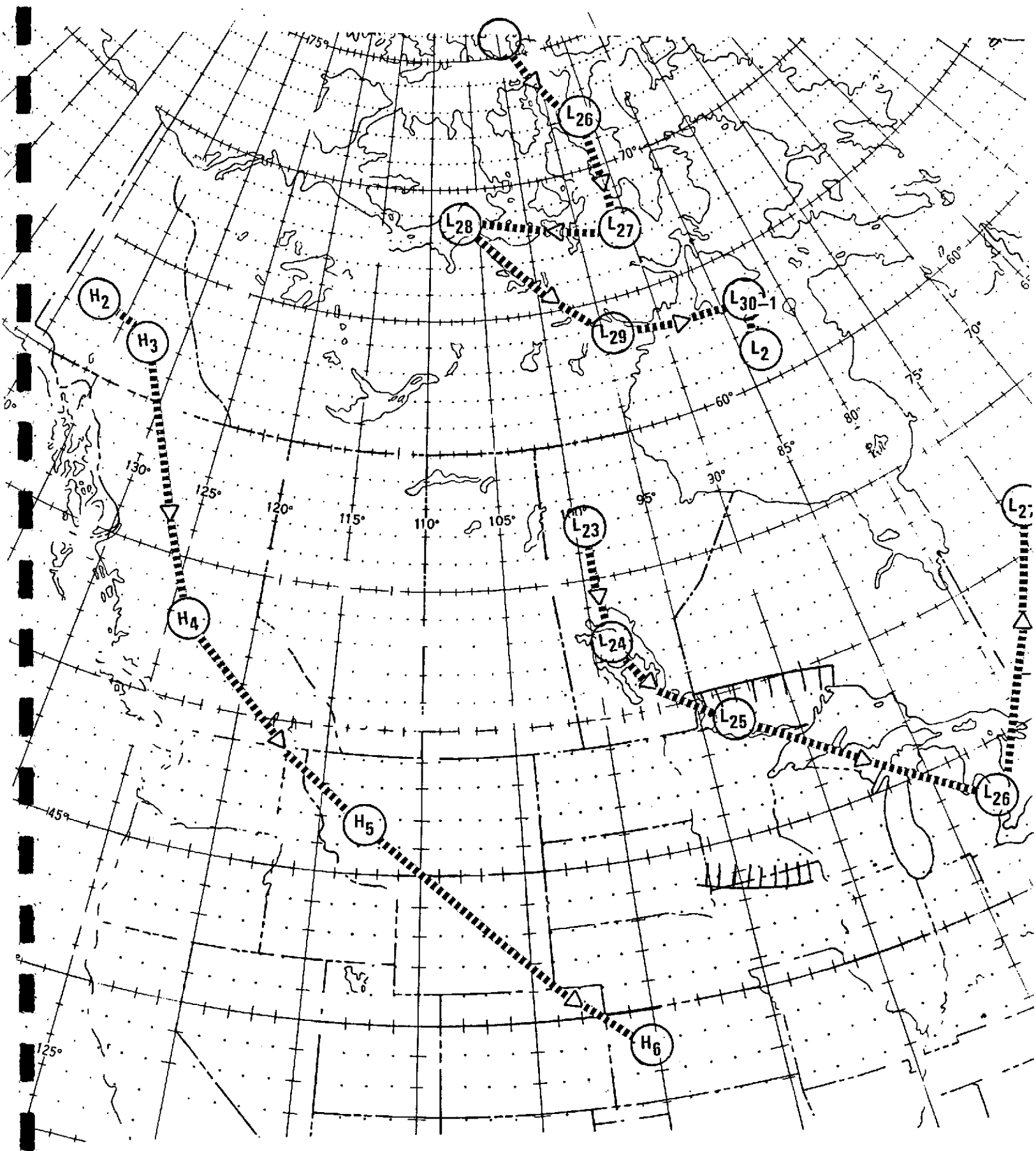


FIGURE 3. MOVEMENT OF AIR MASSES IN CENTRAL NORTH AMERICA BETWEEN 23 NOV 72 AND 6 DEC 72.
(H = High Pressure Mass; L = Low Pressure Mass; Subscript Indicates Day of Month; Observed Transition Zone Indicated)

3.1.2 Comparison With Weather Data

Besides possibly influencing the paths of weather systems across central North America, the transition zone may modify or otherwise affect the magnitude and distribution of important climatological parameters such as temperature and wind vector. Intuitively the transition zone represents a region of considerable convective turbulence, greater than average cloud cover, and above normal temperatures and precipitation. These conditions should come about as a result of the flux of large quantities of heat and water vapor from rapidly cooling lake surfaces to the lower atmosphere. A scenario such as this is amenable to testing by local and regional weather data, and this has been the aim of recent work in this study. Some preliminary findings are reported below.

3.1.2.1 Pressure (Intensification)

An analysis of the low pressure system traversing the transition zone during the period October 6-8 (Figure 4) shows that the system underwent considerable intensification. The system's minimum pressure decreased by 20 mb while in transit over the TZ. Precipitation associated with this storm showed a definite increase with time; the maximum amounts were found in northwest Ontario, probably just south to the TZ. The transition zone could have played a role in the deepening of this storm and in the increased precipitation, but the proximity of Hudson Bay (Figure 4) may have been the predominant factor.

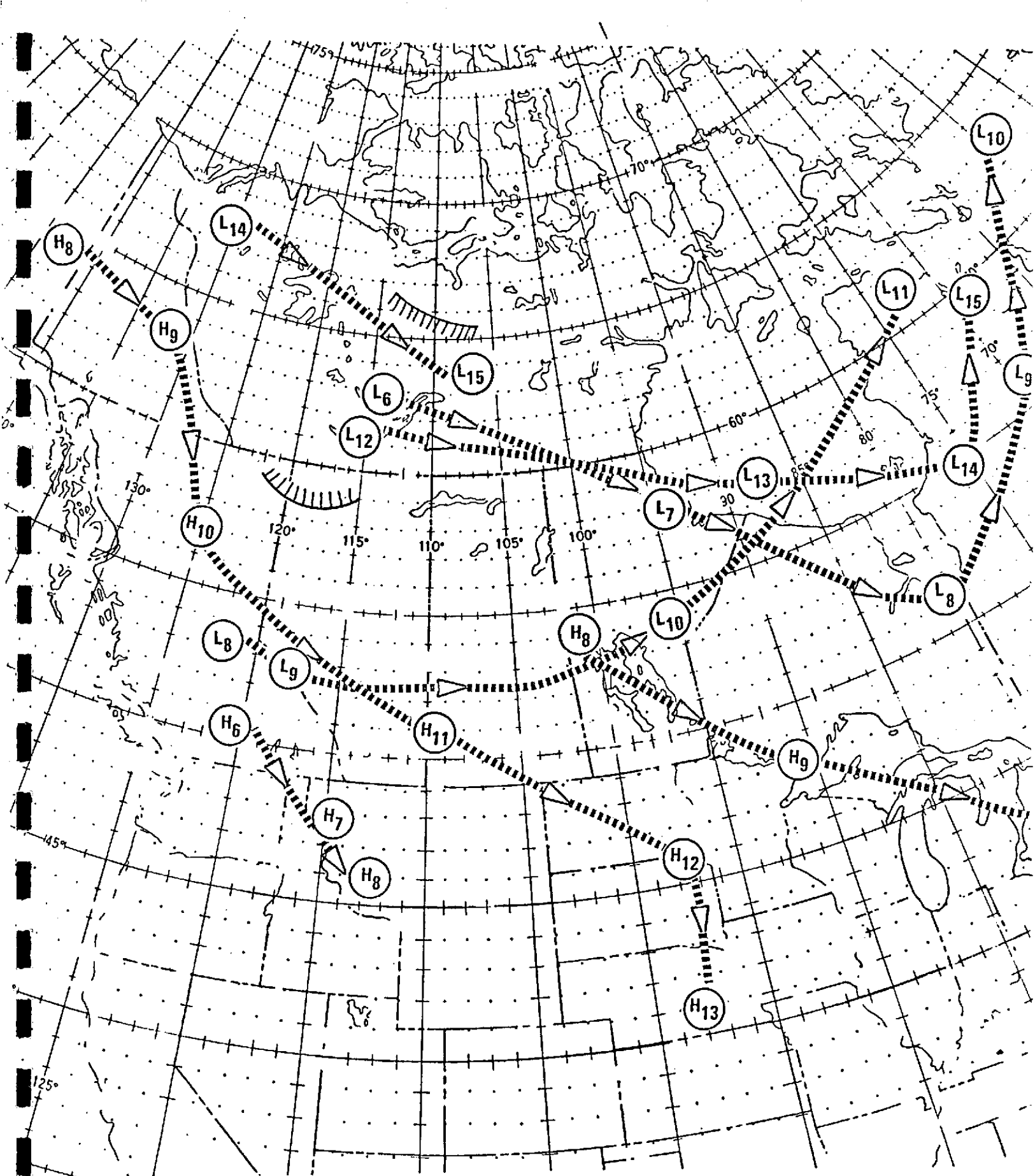


FIGURE 4. MOVEMENT OF AIR MASSES IN CENTRAL NORTH AMERICA BETWEEN 06 OCT 72 AND 15 OCT 72. (H = High Pressure Mass; L = Low Pressure Mass; Subscript Indicates Day of Month; Observed Transition Zone Indicated)

The influence of Hudson Bay can be inferred by the observed pressure intensification of the low pressure systems shown in Figure 4. Table 1 gives the pressure center minimum for each of these systems as a function of time. As previously described, pressure system 1 attained a 20 mb drop while migrating along this transition zone. Pressure system 2, which remained south of the TZ while crossing central North America, actually weakened on October 10; however, after crossing Hudson Bay the system reintensified by 7 mb. Pressure system 3 traveled rapidly through the TZ without undergoing any apparent change; after crossing Hudson Bay the system had intensified by 9 mb. Pressure system 4, which remained entirely within the transition zone, intensified by 11 mb.

An examination of cyclonic systems for the remainder of October and November revealed a similar intensification pattern: (a) those systems moving along the TZ intensified by about 10 mb, (b) crossing Hudson Bay produced an intensification of about 10 mb or less, and (c) low pressure systems outside the TZ experienced erratic pressure changes with net decreases of less than 10 mb. Apparently, on the basis of these results, the transition zone can influence cyclonic intensification as well as direction of flow.

Anticyclonic intensification offers a less consistent picture for the 1972 freeze season. Several polar continental highs whose centers passed just to the north of the TZ actually intensified (e.g., increased maximum pressure). No systematic variations in pressure change were observed in any of the anticyclones whose movements were tracked.

Table 1. Cyclonic intensification through the transition zone for early October 1972 (see Figure 4).
Pressure center minima given in millibars.

		<u>Low Pressure System</u>			
	<u>Date</u>	<u>1</u>	<u>2*</u>	<u>3</u>	<u>4</u>
October	6	999	---	---	---
	7	992	---	---	---
	8	979	1007	---	---
	9	967	994	---	---
	10	972	1001	---	---
	11	---	994	---	---
	12	---	---	1007	---
	13	---	---	1005	---
	14	---	---	996	1014
	15	---	---	995	1003

* Pressure system 2 is assumed to pass south of the transition zone.

3.1.2.2 Precipitation and Dew Point

In order to estimate the transition zone's effect on precipitation, weather data from meteorological stations were combined and averaged over relatively small time intervals. Nine stations were selected at random for each averaging interval: 3 north of the TZ, 3 within the TZ, and 3 south of the TZ. Results of averaging total precipitation are given in Table 2. Averaging intervals were selected to coincide with known positions of the transition zone, leading to small gaps in the record.

Consistent trends in precipitation are not apparent from the short-term averaged data; however, the grand average shows that somewhat less precipitation was recorded in the transition zone as opposed to areas both north and south. This result is in agreement with the previous intensification studies which suggested that the TZ served as a source region for cyclonic storms - moisture accumulated from lakes within the TZ would be released outside the zone.

In addition to average precipitation values, time-averaged dew points and dew point temperature differences were also calculated for certain weather stations during the month of October. In almost every case the dew point temperature differences were smaller north of the transition zone, indicating that this was the region of moister air. However, this result could well be an artifact of the data since only minimum temperature data from the North American Surface Charts were available to make the calculation. Radiational cooling effects, especially from snow and ice cover north of the TZ, would tend to artificially lower the dew point temperature difference.

Table 2. Space-Averaged precipitation (inches) reported from weather stations north of the transition zone (NTZ), within the transition zone (TZ), and south of the transition zone (STZ), 1972 freeze season

<u>Location</u>	<u>October 6-15</u>	<u>October 16-20</u>	<u>October 24-31</u>	<u>November 3-8</u>	<u>November 11-17</u>	<u>Freeze Season Average</u>
NTZ	0.40	0.10	0.48	0.18	0.22	0.28
TZ	0.36	0.02	0.16	0.35	0.13	0.20
STZ	0.54	0.0	0.62	0.07	T	0.25

3.1.2.3 Cloud Cover

Quantitative records of cloud cover were not available from the weather data base used in this investigation. However, some qualitative estimates of clouding can be made from the ERTS imagery of the study area. ERTS data were collected for approximately 40% of all possible scenes during the 1972 freeze season. Assuming that cloud cover was the principal constraint in taking imagery, this estimate gives some indication of the effect cloud cover can have during the freeze season [1]. Scattered views of the freeze transition zone have corroborated heavy cloud cover over the TZ, especially in the vicinity of the southern boundary. Actual estimates of cloud cover percentage both within and outside the TZ have not as yet been made.

3.1.2.4 Temperature (Running Mean Temperature)

An objective of this investigation was to test the running mean temperature criterion proposed by McFadden [8]: lakes whose mean depths exceed 6 meters freeze over very close to the intersection date of the 40-day running mean air temperature (RMT_{40}) and the freezing temperature ($32^{\circ}F$). As previously discussed, the ERTS data are largely unable to provide exact lake freezing dates. Ground observations of freezing dates are available, however, from the Canadian Environment Weather Service. Using this information, McFadden's criterion was applied to two Saskatchewan lakes: Cree Lake and Lac LaRonge. Results of the RMT_{40} calculation are shown in Table 3. Whereas LaRonge shows fair agreement between predicted and observed freeze dates, Cree Lake differs substantially. Although both lakes have approximately identical mean depths, Cree Lake has a much larger maximum depth, implying an anomalous deep depression. This depression could account for the lack of agreement with the RMT_{40} predicted freeze date for this lake.

Table 3. Comparison of observed lake freeze-over dates with
RMT₄₀ predicted freeze dates (1972)

<u>Lake</u>	<u>Area (km²)</u>	<u>Max Depth (m)</u>	<u>Mean Depth (m)</u>	<u>Observed Freeze Date</u>	<u>Predicted Freeze Date</u>
Cree	1155	60	15	November 6	October 18
LaRonge	1178	38	13	November 7	November 2

3.1.2.5 Wind

No comparisons of wind vector and transition zone migration have been made.

3.2 THAW SEASON (1973)

During the reporting period, analysis of imagery taken during the 1973 thaw season was begun. On the whole, efforts to detect the lake thaw transition zone were highly successful. This could be attributed to the lack of extensive cloud cover over the zone; the limiting factor in delineating the zone was the detectability of thin ice on small ($< 10 \text{ km}^2$) lakes. ERTS band 7 proved to be most efficient for this purpose, and this band also proved to enhance early thaw features not readily visible in bands 4 and 5.

Early thaw features in lakes that appear on ERTS imagery include: denudation of snow cover, open fractures, swarms of fractures, shoreline open water, open water in the vicinity of inlets and outlets, a mottled surface, and varying gray levels of reflectance from the surface. One or more of these features may be visible for any given lake in a region, but the appearance of thaw features seems to be almost simultaneous for all lakes of a region. Consequently, an ice decay boundary (IDB) can be discerned on the imagery separating those lakes which display some thaw feature from lakes which appear solidly frozen over.

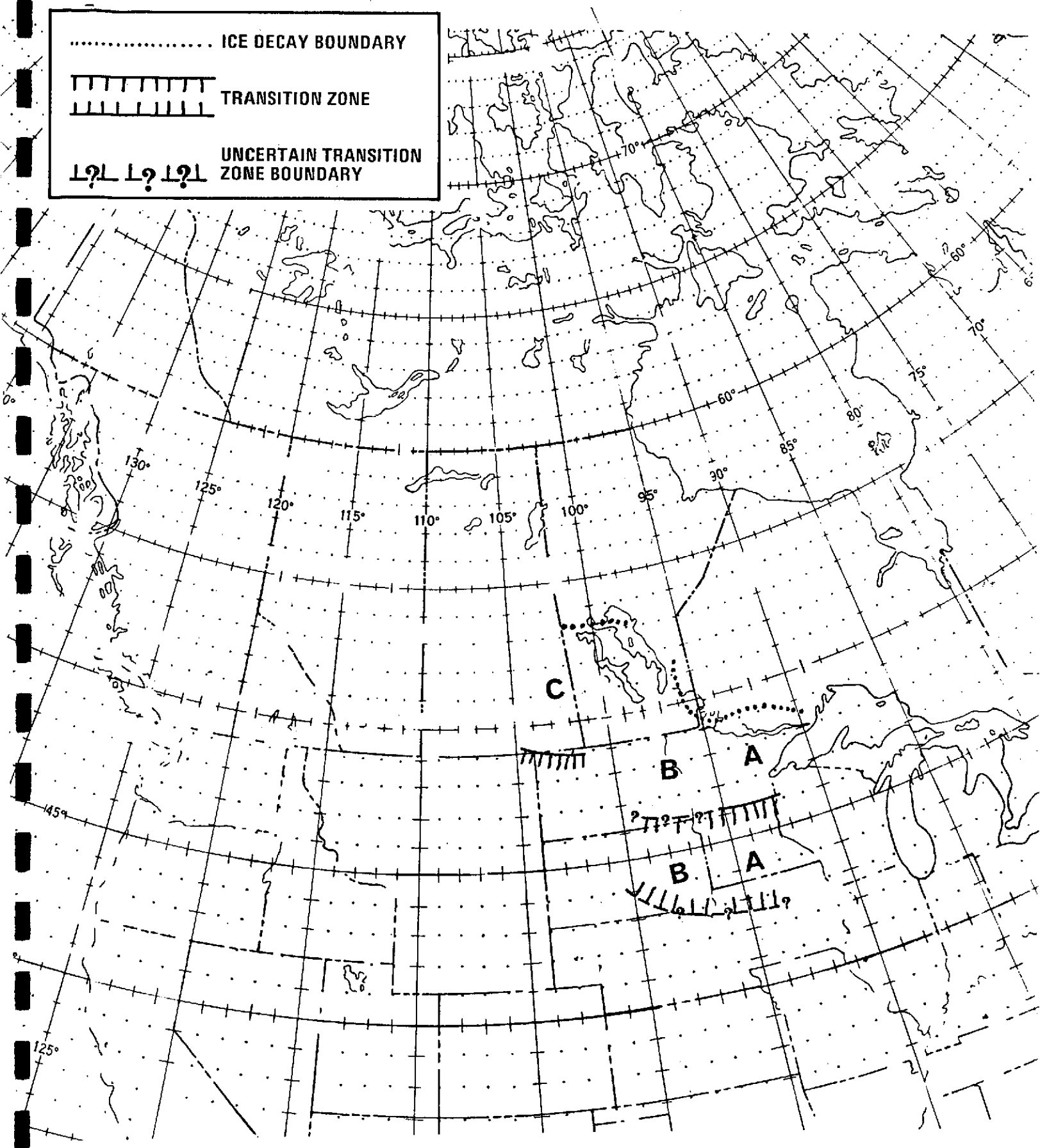
Observed thaw transition zone boundaries and ice decay boundaries for the month of March 1973 are displayed on Figure 5. The IDB can shift dramatically in just a day or two, probably in response to rapid warming trends. This movement contrasts with that for the TZ for which considerable thermal inertia obviates any radical boundary changes.

Thus far imagery analysis for the 1973 thaw season has progressed well into April. The results of that analysis will be presented in the next bimonthly progress report.

3.3 MEAN DEPTH PREDICTION

An important limnological objective of this investigation was to estimate the approximate mean depths of lakes on the basis of their relative freeze dates. Since lakes freeze by giving up heat from their water mass to the atmosphere, lake freeze dates could function as a relative measure of water mass. The mean depth, defined as lake volume divided by surface area, can serve as the unit of water mass.

In order to provide an absolute measure of mean depth variation with freeze date, historical freeze data were collected for lakes of known morphometry [1]. This information was reduced, and lakes with fewer than 4 freeze observations were neglected. Since a lake's freezing date is also a function of latitude, an allowance was made for this dependency. A plot of the resultant data showing mean freeze date as a function of latitude is given in Figure 6. As might be expected, the mean freeze date generally increases (i.e., becomes later) as the latitude decreases. The trends become somewhat more pronounced after isopleths of constant mean depth are drawn. These show that a simple linear relationship between latitude, mean depth,



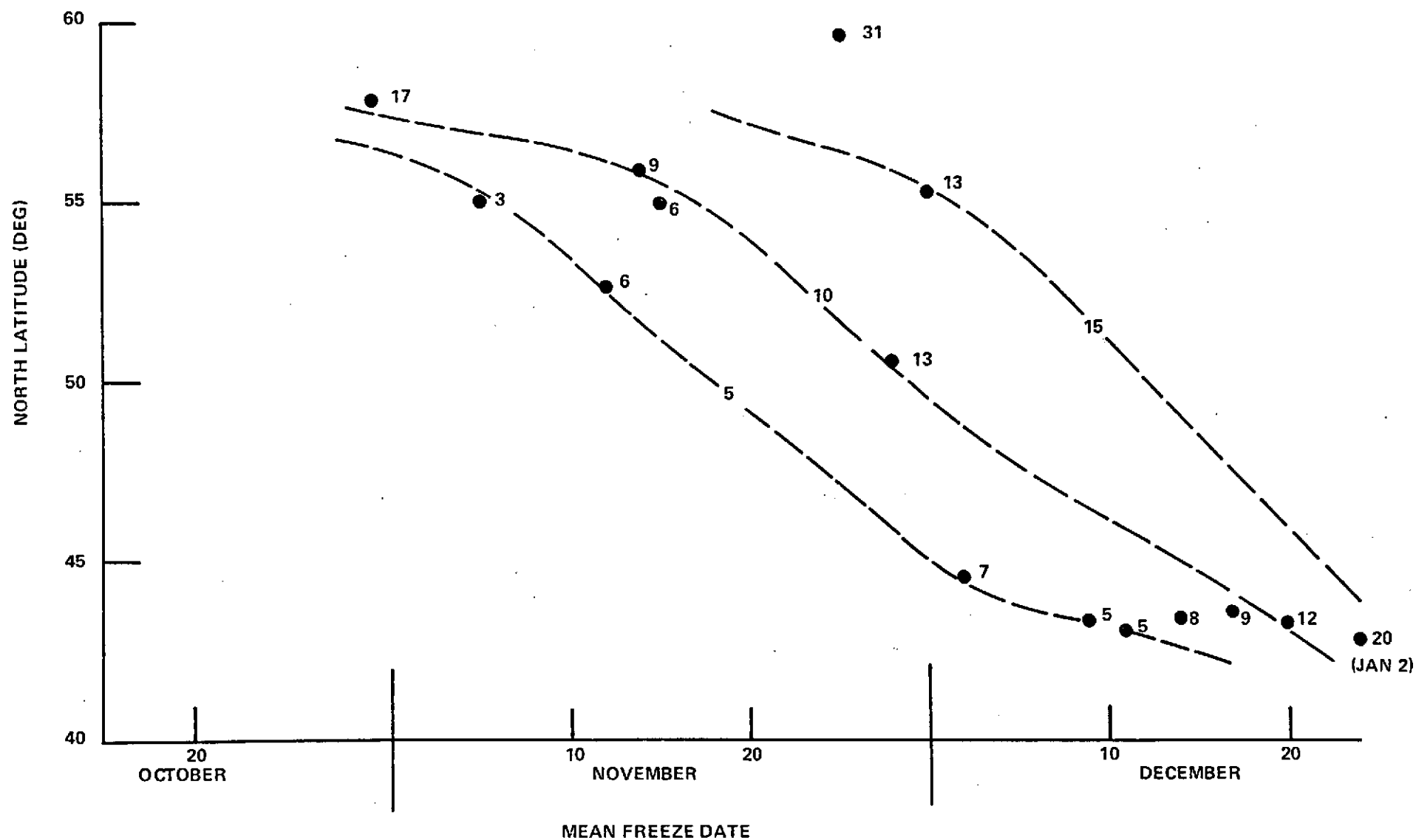


FIGURE 6. LAKE MEAN DEPTH VARIATION AS A FUNCTION OF LATITUDE AND MEAN FREEZE DATE. ONLY LAKES WITH FOUR OR MORE FREEZE DATE OBSERVATIONS USED. NUMBERS ON FIGURE INDICATE LAKE MEAN DEPTH; ISOPLETHS OF MEAN DEPTH ALSO SHOWN.

and mean freeze date is unlikely over the ranges of all variables. However, a regular, nonlinear relationship might exist. The lack of data between 45°N and 50°N latitude precludes drawing any inferences at this time, but the 24-day freeze date variation of lakes clustered at 43°N latitude (Figure 6) is encouraging.

Obviously, if a family of curves can be drawn relating freeze date to mean depth, the utility of ERTS as a hydrographic survey tool would be greatly enhanced. Large, uncharted lake groups might be initially surveyed by satellite on the basis of their relative freezing dates.

SECTION 4.0

CONCLUSIONS

The investigation to date has produced the following consistencies or trends in the relative movements of the lake freeze transition zone and dominant pressure centers:

- Many upper latitude cyclonic storms originate in and/or travel through the transition zone,
- Polar continental high pressure centers move along the borders of the transition zone but fail to pass through the zone,
- Polar outbreak (arctic) high pressure centers move apparently unaffected through the transition zone.

Associated with the migration of low pressure centers through the transition zone is a relatively intense deepening of the pressure minimum by about 10 mb and slightly greater precipitation for those areas outside the transition zone.

The findings have tended to corroborate an interdependence of lake freezing and mesoscale meteorology---an interdependence whose reality was the motive force of this investigation.

SECTION 5.0 RECOMMENDATIONS

The work to this point has produced some reasonable, yet inconclusive, correlations between the lake freeze transition zone and regional climatology. The analytical comparisons applied to the 1972 freeze season should be applied similarly to the 1973 freeze. Another season's data would be invaluable to validate the apparent correlations discussed in the report. In this regard the analysis of more and varied weather data than has been considered to date should be an objective of future work under this contract.

It is recommended that the techniques developed for transition zone-to-weather comparisons during the freeze season likewise be adapted to the thaw season. The 1973 thaw season has shown great promise for supplying a maximum amount of observational data from ERTS; we believe that data can be optimized most efficiently through a comparative effort of the type reported here.

SECTION 6.0

REFERENCES

1. Jelacic, A.J., The Interdependence of Lake Ice and Climate in Central North America, Interim Report for the Period December-May, 1973, NASA Contract NAS 5-21761, 29p., 1973.
2. Wolf Research and Development Corporation, Type I Contract Report No. 5, NASA Contract No. NAS 5-21761, 10 August 1973.
3. Discipline Panel Review, The Interdependence of Lake Ice and Climate in Central North: Summary of Investigation, presented by A.J. Jelacic, NASA/GSFC, October 29, 1973.
4. Based upon lake ice observations supplied to this investigation by the Environment Weather Service of Canada, June 1973.
5. Weatherwise, 26, no. 1, February 1973.
6. Climatological Data (by State), Environmental Data Service, NOAA, U.S. Dept. of Commerce.
7. Meteorological Observations in Canada, Monthly Record, Environment Canada, November 1972.
8. McFadden, J.D., The Interrelationship of Lake Ice and Climate in Central Canada, ONR Contract Nonr 1202(07), Technical Report No. 20, 120 p., 1965.